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ABSTRACT

This booklet contains a programmed lesson on the properties of sea water. It is designed to allow students to progress through the subject matter at their own speed. Since it is written in linear format, it is suggested that students proceed through the program from "frame" to succeeding "frame." Instructions for the students and a list of lesson objectives are included. (JN)

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SOME PROPERTIES OF SEA WATER
A UNIT OF PROGRAMMED INSTRUCTION

Department of Arts and Sciences

Maine Maritime Academy

Castine, Maine 04420

October, 1984

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PROPERTIES OF SEA WATER

INSTRUCTIONS

This booklet contains a programmed lesson on the properties of sea water. It was designed to allow you to progress through the subject matter at your own speed. It is written in a linear format; that is, you should work through the program from "frame" to succeeding "frame".

Complete each frame in the program and record your responses in the space to the left of frame. Keep the succeeding frame covered until you have made your response to a particular frame. As you make the required responses to a frame, check them to be sure they are correct. If you make an error, turn back and review until the point is clarified. If you become confused, or if there is some material which you do not understand, ask your instructor for assistance.

After you have read the Introduction and the objectives, turn to Frame 1 and begin the program.

SUGGESTED READING TIME 48 MINUTES

PROPERTIES OF SEA WATER

INTRODUCTION

Sea water, in addition to having the unique qualities of pure water, has some distinct qualities of its own. For example, sea water contains, in dissolved form, all the known gases found in the atmosphere. Sea water also has, in solution, nearly all the elements, minerals, and salts known to science today.

Also, there are certain physical properties possessed by sea water which makes it quite different from other water. To assist you in understanding the effects of sea water on the equipment, methods, and techniques used in predicting and operating in the ocean environment, it is essential that the properties of sea water covered in this programmed lesson be understood.

PROPERTIES OF SEA WATER

OBJECTIVES

Upon completion of this programmed lesson, students should be able to:

1. LIST the three major physical properties that control sea water physics, and identify the most important controlling property.
2. COMPLETE a statement that describes the major heating and cooling factors of the open ocean.
3.
 - a. WRITE the temperature range found on the surface of the open ocean.
 - b. WRITE the average diurnal temperature range of the surface of the open ocean.
 - c. COMPLETE a statement that describes the latitudinal variation of temperature in the oceans.
4.
 - a. WRITE the unit used to express pressure in oceanography.
 - b. COMPLETE a statement which expresses the relationship between depth and pressure.
5.
 - a. WRITE the definition of salinity.
 - b. WRITE the symbol used to express salinity.
 - c. WRITE the normal range of salinity values found in the open ocean.
 - d. WRITE the controlling factor in average surface salinity distribution.
 - e. MATCH the terms maximum salinity, minimum salinity, and absolute minimum salinity with the geographic area in which each is located.
 - f. MATCH the terms annual salinity maximum and annual salinity minimum with the season of the year in which each occurs.
6. COMPLETE statements that describe the effects of changes in temperature, salinity, and pressure on the density of sea water.
7.
 - a. STATE the normal change in density with depth.
 - b. MATCH the terms stable and unstable, as used in oceanography, with descriptive statements of each condition.
8. MATCH the terms convective mixing and mechanical mixing with descriptive statements of each.

9. MATCH the major processes which affect changes in sea-surface density with statements which describe how each process affects sea-surface density.
10. MATCH significant physical and chemical properties of sea water with descriptive statements related to each property.
11. IDENTIFY the equation which expresses the oceanic heat budget from a given list of equations.

	1. There are three major physical properties that control sea water physics. In the following sequence, you should learn these three properties, and which of these three properties is the most important in controlling sea water physics. NO RESPONSE
	2. The first of the three major physical properties that control sea water physics, and perhaps the most important property, is TEMPERATURE. Temperature is a measure of the warmth or coldness of a substance with reference to some standard value. Since nearly all other physical and chemical properties of sea water are dependent on the sea water temperature, we classify temperature as the <u>most/least</u> important physical property. (Circle one)
most	3. The second of the three major physical properties that control sea water physics is PRESSURE. Pressure is a force per unit area. In oceanography; however, pressure is usually a measure of depth, since a usable ratio of pressure to depth has been established. For routine oceanographic measurements, atmospheric pressure is always neglected, and the pressure at the sea surface is considered zero, while maximum pressure is always at maximum depth. The reason submarines have an established crush depth, which they must not exceed, is because of the increasing _____ with depth in the oceans.
pressure	4. The two major physical properties that control sea water physics are, in decreasing order of importance, _____ and _____.
temperature pressure	5. The third major physical property that controls sea water physics is SALINITY. Salinity is defined as the total amount of solid material dissolved in sea water. Salinity is not, as the name implies, just the dissolved salt in the sea water. It includes all the dissolved material contained in sea water. To express the total dissolved materials in sea water, we may use the term _____.

salinity	6. Match the terms in column A below with the correct statements in column B. <table> <tr> <th><u>A</u></th><th><u>B</u></th></tr> <tr> <td>_____ Pressure</td><td>a. Measure of warmth or coldness of a substance.</td></tr> <tr> <td>_____ Temperature</td><td>b. Basically a function of depth, as used in oceanography.</td></tr> <tr> <td>_____ Salinity</td><td>c. May be described as the weight of sea water.</td></tr> <tr> <td></td><td>d. The total amount of solid material dissolved in sea water.</td></tr> </table>	<u>A</u>	<u>B</u>	_____ Pressure	a. Measure of warmth or coldness of a substance.	_____ Temperature	b. Basically a function of depth, as used in oceanography.	_____ Salinity	c. May be described as the weight of sea water.		d. The total amount of solid material dissolved in sea water.
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	d. The total amount of solid material dissolved in sea water.										
b. a. d.	7. On the lettered lines below, list the three major physical properties that control sea water physics, and place an "X" on the short line to the left of the most important controlling property. _____ a. _____ b. _____ c. _____										
a. Temperature	8. The temperature in the open ocean varies between approximate limits of -2°C to $+30^{\circ}\text{C}$. The lower limit (-2°C) is regulated by the freezing point of sea water, which is always warmer than (above) -2°C; consequently, sea ice forms before the water temperature falls below this level. Circle the letter of the correct temperature range in the open ocean. a. -2°F to $+30^{\circ}\text{F}$ b. -2°C to $+30^{\circ}\text{C}$ c. $+2^{\circ}\text{C}$ to -30°C.										
b.	9. The upper temperature limit ($+30^{\circ}\text{C}$) is maintained as as result of the interaction between the heating capacity of the sun (the major heat source of the oceans) and evaporation (the major cooling process of the oceans). As the sun increases the temperature of the sea water, evaporation speeds up until a balance is reached. Judging by the temperature limits given above, this balance is reached when the sea water temperature reaches _____.										

+30°C	10. On the line below, write the temperature range found on the surface of the open oceans. _____												
-2°C to +30°C	11. If you read frame 9 very carefully, you will recall that the major heat source and the major cooling process of the oceans were mentioned. Match the items in column A below with the correct item in column B. <table> <thead> <tr> <th data-bbox="539 576 979 607">A</th><th data-bbox="979 576 1378 607">B</th></tr> </thead> <tbody> <tr> <td data-bbox="539 635 979 666">_____ Major Oceanic heat source</td><td data-bbox="979 635 1378 666">a. Advection</td></tr> <tr> <td data-bbox="539 693 979 752">_____ Major oceanic cooling process</td><td data-bbox="979 693 1378 725">b. Sun</td></tr> <tr> <td></td><td data-bbox="979 752 1378 784">c. Evaporation</td></tr> <tr> <td></td><td data-bbox="979 811 1378 842">d. Moon</td></tr> <tr> <td></td><td data-bbox="979 870 1378 901">e. Condensation</td></tr> </tbody> </table>	A	B	_____ Major Oceanic heat source	a. Advection	_____ Major oceanic cooling process	b. Sun		c. Evaporation		d. Moon		e. Condensation
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_____ Major Oceanic heat source	a. Advection												
_____ Major oceanic cooling process	b. Sun												
	c. Evaporation												
	d. Moon												
	e. Condensation												
b. c.	12. The major heat source of the ocean is the _____; the major cooling process is _____.												
sun evaporation	13. Generally, sea surface temperatures decrease (get colder) with an increase in latitude (moving from the equator toward either pole). The maximum surface temperature, however, does not occur at the geographical equator (0°), but is displaced several degrees north of the geographical equator in the vicinity of the THERMAL EQUATOR. Keeping in mind that sea surface temperatures usually decrease from the thermal equator poleward. We would expect to find sea surface temperatures at the geographical equator <u>warmer/cooler</u> than temperatures at the thermal equator. (circle one)												
cooler	14. Latitudinal (north-south) variations of temperature in the open oceans show maximum sea surface temperatures at the <u>poles/thermal equator/geographical equator</u>, (circle one) decreasing <u>equatorward/poleward</u>. (circle one)												

thermal equator poleward	15. In addition to surface temperature variation caused by geographical distribution, there are diurnal surface temperature variations (daily or from day to day). Diurnal variations are slight, averaging from 0.2°C to 0.3°C, and are related to the amount of heat absorbed from the sun during the day and radiated from the sea surface at night. Additionally, such things as cloud cover and precipitation affect the diurnal range. Circle the letter of the correct diurnal temperature range in the open ocean. a. 0.2°F to 0.3°F b. 2.0°C to 3.0°C c. 0.2°C to 0.3°C												
c.	16. Diurnal or daily sea surface temperature variations are <u>slight/great</u>, ranging on the average from _____ (circle one) _____ (Diurnal range)												
slight 0.2° to 0.3°C	17. Examine the temperature ranges below, and place an "X" on the line beside the temperature limits found in the open oceans, and place a "Y" on the line beside the diurnal sea surface temperature range. ____ a. -0.2°C to +0.3°C ____ c. 0.2°C to 0.3°C ____ b. -2°C to +30°C ____ d. 0.2°C to 30.0°C												
<u>X</u> b. <u>Y</u> c.	18. Now, let's consider pressure and its related concepts. In oceanography, pressure is often expressed in DECIBARS and is a function of depth, such that 1 meter in depth is equal to roughly 1 decibar of pressure. Using this 1 to 1 ratio, complete the table below. <table border="1"> <thead> <tr> <th>DEPTH Meters</th> <th></th> <th>PRESSURE Decibars</th> </tr> </thead> <tbody> <tr> <td>10</td> <td>=</td> <td>_____</td> </tr> <tr> <td>_____</td> <td>=</td> <td>35</td> </tr> <tr> <td>150</td> <td>=</td> <td>_____</td> </tr> </tbody> </table>	DEPTH Meters		PRESSURE Decibars	10	=	_____	_____	=	35	150	=	_____
DEPTH Meters		PRESSURE Decibars											
10	=	_____											
_____	=	35											
150	=	_____											

10 = <u>10</u> <u>35</u> = 35 150 - <u>150</u>	19. In meteorology, pressure is normally expressed in millibars, but in oceanography, pressure is expressed in _____.
decibars	20. One meter of depth in the ocean is equal to _____ of pressure.
one decibar	21. The one parameter most often mentioned in any discussion of sea water is salinity. Salinity is used to describe the total amount of dissolved material in sea water. It is expressed in parts of dissolved material per thousand parts of water. Salinity may also be expressed as grams per kilogram (grams per thousand grams). The symbol typically used to represent salinity is ‰. This symbol follows the numerical value for salinity and is read as salinity in parts per thousand. Using the symbol for salinity, we would write a salinity of 35 parts per thousand as _____.
35 ‰	22. The total quantity of dissolved material in sea water expressed in parts per thousand is the definition of _____.
salinity	23. Salinity is the total amount of _____ material in sea water expressed in _____ per _____.
dissolved parts thousand	24. The _____ amount of dissolved _____ in sea water expressed in _____ per _____ is the definition of _____.
total material parts thousand salinity	25. On the lines below, write the definition of salinity. _____ _____ (for answer, see frame 21 or 22)

26. On the line below, write the symbol used to express salinity.

°/oo

27. Like temperature, salinity varies latitudinally and seasonally. The normal range of salinities found in the open ocean is from 33°/oo to 37°/oo, making the average about 35°/oo. The controlling factor in salinity distribution is the difference between evaporation and precipitation; that is, in areas where evaporation exceeds precipitation, you would expect to find relatively high salinity, because evaporation removes only the water leaving a higher ratio of dissolved solids in the remaining water. In the vicinity of 20° to 30° north and south latitude, we find an area where evaporation greatly exceeds precipitation. In these regions, we would expect to find maximum/minimum salinity.
(circle one)

maximum

28. In areas where precipitation exceeds evaporation, more water is added to ocean than leaves, reducing the ratio of dissolved material to water. Such an area is found near the thermal equator where frequent showers and thundershowers add large amounts of fresh water to the sea water. Near the thermal equator, we would expect to find an area of maximum minimum salinity.
(circle one)

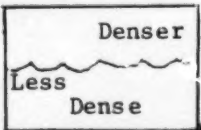
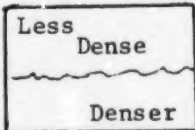
minimum

29. The lowest salinity values found in the oceans, or the absolute minimum salinity, are found in areas near the poles as a result of abundant precipitation, ice melt and low evaporation. To summarize then, from the thermal equator toward either pole, the following conditions exist:

- a. At the thermal equator, an area of maximum/minimum salinity exists.
(circle one)
- b. Between 20° and 30° north and south latitude, an area of maximum/minimum salinity exists.
(circle one)
- c. At the poles, an area of absolute maximum/minimum salinity will be found.
(circle one)

evaporation precipitation	36. Annual minimum salinity values occur during the fall months, because during the summer months, <u>precipitation/evaporation</u> exceeds <u>precipitation/evaporation</u>. (circle one) (circle one)
precipitation evaporation	37. Match the terms below with the season of the year in which each occurs. _____ Annual salinity maximum a. Summer _____ Annual salinity minimum b. Winter c. Fall d. Spring
d. e.	38. You now have a basic knowledge of the three major physical properties; temperature, pressure and salinity, that control sea water physics. In the following sequences, you will learn how these properties are related to and affect sea water density. NO RESPONSE.
	39. Ordinarily, in physics, we define density as mass per unit volume. In oceanography, density may be referred to as the weight of sea water. The density, or weight, of sea water is controlled by three factors: Temperature, pressure and salinity. First, let's consider the effects of changes in temperature on the density of a given volume of sea water. If we increase the temperature of a given volume of water, the water expands with a corresponding decrease in density. If the temperature of a volume of sea water decreases, we expect the density to _____.
increase	40. If the temperature of sea water is changed from 20°C to 30°C, the density of this water will: <u>increase/decrease</u> as a result of <u>expansion/contraction</u>. (circle one) (circle one)

decrease expansion	41. A direct relationship exists between changes in salinity and changes in density; an increase in salinity causes an increase in density. In this case, additional solid material (mass) is being added to the volume of water. On the basis of this direct relationship, if the salinity of a volume of water decreased from 37°/oo to 33°/oo, the density of the volume of water would <u>increase/decrease</u> . (circle one)
decrease	42. Complete the statements below. a. A temperature increase causes a density <u>increase/decrease</u> ; a decrease in temperature (circle one) results in a density <u>increase/decrease</u> . (circle one) b. An increase in salinity will <u>increase/decrease</u> (circle one) density; a decrease in salinity will <u>increase/decrease</u> density. (circle one)
a. decrease increase b. increase decrease	43. Like salinity, a direct relationship also exists between changes in pressure and density. An increase in pressure (depth) causes an increase in density because of compression. Conversely, a decrease in pressure results in an expansion of the water volume and an <u>increase/decrease</u> in density. (circle one)
decrease	44. We can summarize, then, by saying that an increase in pressure will <u>increase/decrease</u> density, and a (circle one) decrease in pressure will <u>increase/decrease</u> density. (circle one)
increase decrease	45. Under normal conditions, density will increase with depth. It may do so as a result of decreasing temperature, increasing pressure or increasing salinity, or any combination of changes in these properties. When density increases with depth, less dense water overlays denser water, and the water is said to be STABLE. A stable condition exists when sea-water density <u>increases/decreases</u> with depth. (circle one)

increases	46. The density of sea water normally <u>increases/decreases</u> (circle one) with depth. This condition is said to be <u>stable/unstable</u> . (circle one)
increases stable	47. When density decreases with depth; that is, when denser water is overlying less dense water, the water mass is said to be UNSTABLE. An unstable condition exists when sea water density <u>increases/decreases</u> with depth. (circle one)
decreases	48. An unstable condition is not normal; sea water density normally _____ with depth.
increases	49. On the line below, write the normal change in sea water density with depth. _____
density normally increases with depth	50. Label the diagrams below as illustrated STABLE or UNSTABLE conditions.  a. _____  b. _____
a. Unstable b. Stable	51. Match the terms below with the correct descriptive statement of each. _____ Stable _____ Unstable a. Denser water over less dense water. b. Increase in pressure with depth. c. Less dense water over denser water. d. Decrease in salinity with depth.

c. a.	52. When unstable conditions exist, the heavier, denser water sinks through the lighter, less dense water below it. As sinking takes place, mixing also occurs to a depth at which the density is equal to the sinking water. This is termed CONVECTIVE mixing and results from a layer of dense water overlying a layer of less dense water. Convective mixing is one of the major methods by which the mixed layer is formed. If we noticed that a layer of denser water were overlying a layer of less dense water, immediately we would expect _____ mixing to occur.						
convective	53. The other important method by which mixing is accomplished is termed MECHANICAL mixing, and occurs as a result of winds, tides, currents, and the like. Mechanical mixing is a result of some type of physical action and is independent of the stability condition. If we observed increasing density with depth, and yet a deep mixed layer, we would know that this mixed layer was probably the result of _____ mixing.						
mechanical	54. Match the terms below with the correct descriptive statement of each. <table border="0"> <tr> <td>_____ Convective mixing</td> <td>a. Mixing accomplished by wind, wave action, and currents.</td> </tr> <tr> <td>_____ Mechanical mixing</td> <td>b. Mixing accomplished as a result of pressure differences in the water mass.</td> </tr> <tr> <td></td> <td>c. Mixing accomplished as a result of denser water sinking through less dense water.</td> </tr> </table>	_____ Convective mixing	a. Mixing accomplished by wind, wave action, and currents.	_____ Mechanical mixing	b. Mixing accomplished as a result of pressure differences in the water mass.		c. Mixing accomplished as a result of denser water sinking through less dense water.
_____ Convective mixing	a. Mixing accomplished by wind, wave action, and currents.						
_____ Mechanical mixing	b. Mixing accomplished as a result of pressure differences in the water mass.						
	c. Mixing accomplished as a result of denser water sinking through less dense water.						
c. a.	55. There are four major processes which affect changes in sea surface density. Two of these processes, evaporation and ice formation, cause an increase in water density; while precipitation and ice disintegration cause a density decrease. Evaporation and ice formation increase density by removing only pure water from the water mass, leaving a higher concentration of dissolved solid material in the remaining water. Precipitation and ice disintegration, on the other hand, decrease density by adding purer water to the existing water mass, thereby diluting it and decreasing the density.						

NO RESPONSE

56. The two processes which decrease sea surface density are _____ and _____.

The two processes which increase sea surface density are _____ and _____.

precipitation
ice disintegration

evaporation

ice disintegration

57. Match each process below with the statement that describes how the process affects sea surface density.

_____ a. Evaporation _____ c. Precipitation
_____ b. Ice formation _____ d. Ice disintegration

1. Decreases density; pure rain or snow is added and dilutes the sea water.
2. Decreases density; pure water from melting ice is added and dilutes the sea water.
3. Increases density; pure water is removed in the form of water vapor, leaving a higher amount of solid material.
4. Doesn't change density; related to changes in temperature and pressure only.
5. Increases density; pure water is removed, and the saline particles are squeezed out of the ice into the remaining cold water.

3 a.

5 b.

1 c.

2 d.

58. In addition to those properties of sea water already discussed, there are several other properties of somewhat lesser importance, but a knowledge of which will serve to "round out" your understanding of sea water physics. These properties are compressibility, viscosity, transparency and color, electrical conductivity, and sound transmissivity.

NO RESPONSE

59. Compressibility refers to the ability of the molecules to be compressed or expanded. In sea water is slightly compressible; somewhat less than steel. The compressibility of sea water keeps sea level lower than it would be if sea water were not compressible. If the compressibility were zero, the sea level would be about 90 feet higher than it is at present. The ability of sea water to be compressed is important in sound transmission. Viscosity is the resistance of a substance flow. It results from varying degrees of attraction between molecules. Viscosity is important in determining the power and trim requirements of submarines and in determining the sink rate of oceanographic instruments.

Transparency and color each vary considerably in sea water. Transparency is the ability to be seen through and is dependent upon the amount of suspended particles in the water. Color refers to the different shades of blue and green normally observed in the oceans. Coastal water is generally a shade of green; offshore water is normally a shade of blue. Submarines are often painted to match the color of the water in which they normally operate in order to reduce the chance of their being detected visually.

Both transparency and color are important in the visual detection of submerged objects.

NO RESPONSE.

60. Electrical conductivity refers to the ability of a substance to conduct electrical energy. In sea water, electrical conductivity is very poor. Electrical conductivity is related to salinity. Increases in salinity increases the electrical conductivity of the water. Sound transmissivity is the ability of a substance to transmit sound waves. Sound transmission is very good in sea water; about 4.5 times faster in water than in air.

NO RESPONSE

61. Match the properties of sea water below with the descriptive statement related to each.

- | | |
|---------------------------------|----------------------------------|
| _____ a. Compressibility | _____ d. Electrical conductivity |
| _____ b. Viscosity | _____ e. Sound transmissivity |
| _____ c. Transparency and color | |

1. Very poor in sea water; related to changes in salinity.
2. Varies considerably with water depth; important in the visual detection of submerged objects.
3. Resistance to flow; important in determination of the sink rate of oceanographic instruments.
4. Mass per unit volume; may be described as the weight of sea water.
5. Slight in sea water; somewhat less than that of steel.
6. Very good in sea water; about 4.5 times faster in water than in air.

(Answers opposite frame 63)

62. Since temperature is the most important single controlling property of sea water physics, and affects every other property, it is important to understand better the factors that increase and decrease sea water temperature. The major heating and cooling processes of the ocean can be summed up in the oceanic heat-budget equation given below.

$$Q_s = Q_b + Q_h + Q_e$$

$$100\% = 40\% + 5\% + 55\%$$

In this equation:

- Q_s - represents solar radiation or heat from the sun. The sun is the major heat source of the oceans and for practical purposes, the only heat source to be considered.
- Q_b - represents back radiation or heat radiated from the sea surface back to the atmosphere. Since oceanic heat is lost, this is a cooling process and accounts for about 40% of total heat used or released by the seas. Back radiation occurs only when the sea water temperature is higher than the temperature of the air above it.
- Q_h - represents heat conducted from the ocean to the atmosphere by actual contact between atmosphere and ocean. A relatively small amount of heat (about 5%) is lost by this process, because when the lower layer of air is warmed, it rises and is replaced by cooler air. The sea surface temperature is cooled at the same time; thus, each parcel of air that is warmed and replaced, there is less heat difference between air and water. Eventually, the difference becomes zero and heat exchange stops.
- Q_e - represents cooling as a result of the evaporation process. Evaporation is the major cooling process in the ocean. Heat energy is used in the evaporation process, leaving the water cooler. Ordinarily, evaporation is greatest when warm water is overrun by cold air. For this reason, evaporation is the most common cooling process during winter.

Since, over the years, the oceans are not gradually warming or cooling, the heat-budget equation may be stated:

$$\text{Heating} = \text{Cooling}$$

NO RESPONSE.

<u>5</u> a.	63. Match the three cooling factors used in the oceanic heat-budget equation with the symbols used to represent each in the equation.
<u>3</u> b.	
<u>2</u> c.	<u> </u> Back radiation, heat radiated from the sea surface to the atmosphere
<u>1</u> d.	<u> </u> Heat conducted to the atmosphere by actual contact.
<u>6</u> e.	<u> </u> Evaporation.
	1. Q_e
	2. Q_s
	3. Q_b
	4. Q_h
	5. Q_n
3 4 1	64. The major heat source of the oceans is the <u> </u> . Heat received from this source is represented in the heat-budget equation by the symbol <u> </u> .

65. Circle the letter of the heat-budget equation below:

- a. $Q_s = Q_b + Q_h - Q_e$ where Q_s = solar radiation from the sun.
 Q_b = back radiation to the atmosphere.
 Q_h = heat conducted to the atmosphere.
 Q_e = heat released by condensation process.
- b. $Q_s = Q_b + Q_h - Q_e$ where Q_s = solar radiation from the sun.
 Q_b = back radiation to the atmosphere.
 Q_h = heat conducted to the atmosphere.
 Q_e = heat lost by evaporation process.
- c. $Q_s + Q_h - Q_b + Q_e$ where Q_s = solar radiation from the sun.
 Q_h = heat conducted from the atmosphere to the sea.
 Q_b = back radiation to the atmosphere.
 Q_e = heat lost by evaporation process.

Answer to 64.
sun; Q_s

Answer to 65.
b.